Ancient Aurorae
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Ancient Aurorae

*By Richard Stothers**

ANCIENT OBSERVATIONS of the aurora borealis were perforce made visually and in the Western world were recorded almost exclusively by peoples of the Mediterranean basin. It will be useful initially to recapitulate the easily visible features of modern aurorae so that the historical ones can be discussed. Three basic forms occur: (1) rayless forms, such as arcs, bands, and glows; (2) rayed forms, such as draperies and coronae; and (3) flaming aurorae. A rapid pulsation or wavelike motion is sometimes also observed. At low geomagnetic latitudes the usual forms are quite simple, showing little or no motion; the color most frequently observed is red or yellowish white; and the average incidence of visible aurorae is about one per decade, although in Italy the incidence is a few times greater than in Greece. Aurorae at these latitudes do not often appear far from the time of maximum in the eleven-year solar activity cycle.[1] Thus, it is only to be expected that ancient auroral reports must be vague and few in number and must present considerable difficulties of interpretation.

It is my intention in the present paper to trace the history of auroral studies in the ancient Western world, to comment on the partial modern rediscovery of this record, and to propose a classification scheme for ancient aurorae. A new and fully documented catalogue of ancient auroral reports has been compiled for this purpose and will be discussed statistically for whatever implications can be drawn concerning auroral activity in the distant past.

ANCIENT KNOWLEDGE OF AURORAE

The earliest Greek sky myths are possible repositories of information on prehistoric auroral observations.[2] For example, the *Theogony,* a prescientific creation story, records lurid details like "flaming heavens," "fiery sky dragons," and even a "rain of blood."[3] These notions must have persisted for centuries.

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[1]Carl Störmer, *The Polar Aurora* (Oxford: Clarendon Press, 1955).

[2]See J. J. D. de Mairan, *Traité physique et historique de l'aurore boréale* (2nd ed., Paris: Imprimerie Royale, 1754), pp. 462–463 (1st ed. 1733).

[3]Hesiod, *Theogony* 183–184, 689–693, 824–828. Nonnus, many centuries later, interpreted Hesiod's myth of Typhon in terms of "comets," "fiery beams," and "flaming exhalations" (*Dionysiaca* II 198–200, 482–492, 515–516; compare Pliny, *Naturalis historia* II 91; Avienus in Servius, *In Vergilii Aeneadum, ad* X 272). Homer (*Iliad* XI 53–54, XVI 458–459) mentions two mythological "rains of blood," which, however, his later commentator Heraclitus (*Homeric Allegories* 42) interpreted as simply a fall of red-colored raindrops, and the Scholiast (*ad* XI 53–54) as a downpour of human blood that had previously evaporated. Later writers of epic and tragedy also occasionally referred to early "blood rains." Of further interest in connection with possible aurorae are the myth of a "milk rain" when Hera generated the Milky Way (see esp. *Geoponica* XI 19) and the myth of Phaëthon's sky ride, which was interpreted in an explicitly allegorical sense as, i.a., "a mass of sky fire" (pseudo-Aristotle, *De mundo* 400a30–32; Lucretius, *De rerum natura* V 406–408; Philostratus, *Imagines* I 11), "a fiery exhalation" (Domninus in Proclus, *In Platonis Timaeum, ad* 22) and "a comet" (Proclus, *ad* 22; Philoponus, *In Aristotelis Meteorologica, ad* 345a13; Olympiodorus, *In Aristotelis Meteorologica, ad* 345a11). Other mythological "comets" and "torches" are of less interest here. In biblical exegesis, Philo Judaeus (*Quaestiones et solutiones in Genesin* III 14–15) interpreted Genesis 15:17 in terms of Aristotle's "fiery exhalations."

When serious Greek inquiry into nature began in the sixth century B.C., speculation about the origin of "comets" (aurorae?) seems to have been widespread.[4] Ideas that may well encompass auroral phenomena include: "inflammable exhalations from the earth" (Anaximenes) and "moving accumulations of burning clouds" (Xenophanes). In the next century Hippocrates of Chios and his student Aeschylus developed their idea of "reflected sunlight," while in the fourth century Metrodorus of Chios and Heraclides of Pontus favored "illuminated clouds," although Aristotle adhered more closely to the older, sixth-century views. The earliest known Greek account of what is now accepted to be an actual auroral display dates, in its original form, from the fifth century B.C. (probably from the lost treatise of Anaxagoras), and is preserved as a fragment in Plutarch:

> For seventy-five days continually, there was seen in the heavens a fiery body of vast size, as if it had been a flaming cloud, not resting in one place, but moving along with intricate and irregular motions, so that fiery fragments, broken from it by its plunging and erratic course, were carried in all directions and flashed fire, just as shooting stars do.[5]

This event is known to have occurred in 467 (or 468) B.C.

Whatever its antecedents were, the first reliable "scientific" description of an auroral display is generally acknowledged to be that of Aristotle, who wrote (c. 330 B.C.):

> Sometimes on a clear night a number of appearances can be seen taking shape in the sky, such as "chasms," "trenches" and blood-red colours. These again have the same cause. For we have shown that the upper air condenses and takes fire and that its combustion sometimes produces the appearance of a burning fire. . . . The cause of the brief duration of these phenomena is that the condensation lasts for a short time only. Chasms have an appearance of depth because the light breaks out from a dark blue or black background.[6]

Aristotle argues that reflection and attenuation of the fiery light as it passes through the denser, lower air contribute to producing the observed colors, and he clearly implies that the large angular extent and speed of the phenomena confirm their sublunary origin. In another place Aristotle also comments that if the inflammable substance in the sky "extends both lengthwise and breadthwise we often see a burning flame of the kind one sees when stubble is being burnt on ploughland." These remarks could have been precipitated by the spectacular sky displays of 349 and 344 B.C. seen in Greece; it is not necessary to suppose that Aristotle must have been in Macedonia to have seen an aurora.[7]

[4] Aëtius, *Placita* III 2 (Stobaeus, *Eclogae* I 28.1); Hippolytus, *Refutatio* I 6–8; Scholiast to Aratus, *Phaenomena, ad* 1091. An early 6th-century Persian aurora may be recorded in Xenophon, *Cyropaedia* IV 2.15; cf. Dio Chrysostom, *Orations* 36.40 (Zoroastrian aurora?) and Exodus 19:16–20, 20:18, 24:15–18.

[5] Daimachus (4th century B.C.?) in Plutarch, *Lysander* XII 4, trans. Bernadotte Perrin, *Plutarch's Lives* (Cambridge, Mass.: Harvard University Press, 1916). The frequent auroral interpretation of this passage has been most recently defended by P. J. Bicknell, "Did Anaxagoras Observe a Sunspot in 467 B.C.?" *Isis,* 1968, *59*:87–90.

[6] Aristotle, *Meteorologica* 342a34–342b16, trans. H. D. P. Lee, *Aristotle: Meteorologica* (Cambridge, Mass.: Harvard University Press, 1952). W. D. Ross, in *The Works of Aristotle* (Oxford: Clarendon Press, 1931), Vol. III, footnote *ad loc.,* supposes that the chasms are due to cloud coloration. They have also been attributed to the light-stripes that sometimes appear during bright nights (nocturnal airglow) by S. M. Silverman, "On the 'Chasms' of Aristotle and Pliny," *Journal of Atmospheric and Terrestial Physics,* 1962, *24*: 1108–1109. However, the longstanding (de Mairan 1733) auroral interpretation has been upheld, in my opinion definitively, by Francis Celoria, in "The Alleged Dark Segment in Aurora Borealis Displays," *Journal of the British Astronomical Association,* 1968, *78*: 129–132; see also J. L. Ideler, *Meteorologia veterum Graecorum et Romanorum* (Berlin: Nauck, 1832), pp. 49–54.

[7] Aristotle, *Meteorologica* 341b25–27. The display of 349 is recorded in Pliny (*Naturalis historia* II 97) and that of 344 in Plutarch (*Timoleon* VIII 5–7).

Heraclides of Pontus, an associate of Aristotle's, was possibly the first author to discriminate critically between "comets" and "beams, pillars, and all other manifestations of this kind,"[8] although Anaxagoras had already described the object of 467 as a "beam," according to a certain Charmander cited by Seneca, and although Pliny knew, from an unidentified source, about another "beam" seen in Greece in 394.[9] It is likely that Heraclides actually witnessed the "beam" of 373 (or 372), which touched off much speculation by natural philosophers of that time.[10] Thus, by the late fourth century B.C. all the basic features of prominent aurorae visible from low latitudes had been described and speculated upon by Greek natural philosophers.

In the Roman world, legendary memories of a "blood rain" during the reign of King Romulus are preserved by Plutarch.[11] However, the earliest datable Roman aurorae comprise a distinct cluster of events spanning the approximate years 464–459 B.C. They are recorded in the histories of Livy and Dionysius of Halicarnassus. A typical report simply states that "the sky was seen to blaze with numerous fires."[12] A large lacuna in our subsequent record of Roman aurorae extends down to the year 223 B.C. But after that time reports of aurorae are fairly frequent until late in the first century A.D., after which they all but vanish for the next three centuries.

Probably all the Italian reports before the first century B.C. appeared originally in the annual commentaries of the Pontifex Maximus, the source of most of the Roman historical tradition.[13] But these reports of celestial prodigies to be expiated are too brief and naïve to be considered "scientific." In fact, the earliest (and best) surviving examples of Roman scientific writing on aurorae date from the first century A.D. and are due to Manilius, Seneca, and Pliny, who relied either directly or indirectly on earlier Greek treatises for theory but embellished their texts with illustrations drawn from their own experience and from previous Roman writings. Here is a selection of what Seneca had to say on the subject:

> It is time to consider, briefly, other atmospheric fires, of which there are various forms.... There are "trenches": within a surrounding corona there is a great gap in the sky like a hole dug in a circle. There are "barrels": an enormous round mass of fire, like a barrel, either darts by or blazes in one place. There are "chasms": some area of the sky settles and,

[8] Aëtius, *Placita* III 2 (Stobaeus, *Eclogae* I 28.1).

[9] Seneca, *Naturales quaestiones* VII 5.3; Pliny, *Naturalis historia* II 96. Pliny may actually be referring to the "beam" of 373.

[10] See Diodorus Siculus, *Library of History* XV 50.2. Demetrius of Phalerum, in the generation after Heraclides, was another early writer on "beams" (Diogenes Laertius, *Vitae philosophorum* V 81; Achilles Tatius, *Isagoge ad Arati Phaenomena* 34). Aristotle never mentions "beams" but calls the objects of 467 and 373 "comets." On the other hand, he discusses "torches," of which some appear to be morphologically similar to "beams" (see *Meteorologica* 341b1–342b24). Other authors, however, have used the term λαμπάδες rather than Aristotle's δαλοί when referring to these beamlike "torches." But there exists a tradition that Aristotle himself did include "beams" among the "torches" and "comets" (pseudo-Aristotle, *De mundo* 392b4, 395b12; Seneca, *Naturales quaestiones* VII 5.4; Stobaeus, *Eclogae* I 34.2; Olympiodorus, *ad* 344a20). The interesting question of what influence on the early Greek philosophers might have been exerted by imported Chaldean cometary ideas and the related question of what dates should be assigned to the Greek cometographers Epigenes, Apollonius of Myndos, and Artemidorus of Parium are still moot; for differing views cf. Rudolf Hartmann, *De Senecae naturalium quaestionum libro septimo* (Monasterii Guestfalorum, 1911) and Paul Oltramare, *Sénèque: Questions naturelles* (Paris: Belles-Lettres, 1929). Other ancient categories of "comets" will not be discussed here since they have turned out to play no significant role in identifying datable aurorae. In any case, they seem to have been rarely seen toward the north (pseudo-Aristotle, 395b14–15).

[11] Plutarch, *Romulus* XXIV 1. Geoffrey of Monmouth (12th century), *Historia regum Britanniae* II 16, claims that a British "rain of blood" occurred at that time! Two possible aurorae in Vergil's *Aeneid* (VII 142–143, IX 20) are undoubtedly only literary inventions.

[12] Livy, *Ab urbe condita* III 5.14. See also Livy III 10.6; Dionysius of Halicarnassus, *Roman Antiquities* X 2.3. I have retained the traditional dates (which may be a few years too early).

[13] Cicero, *De oratore* II 12.52; Servius, *In Vergilii Aeneadum, ad* I 373; Macrobius, *Saturnalia* III 2.17.

> gaping in hiding—so to speak—sends out flame. The colors of all these are also very numerous: some are a very bright red, some a pale and light flame, some a white light, some flickering, some uniformly yellow and without outbursts or rays. . . . "Beams" and the rarely seen "barrels" . . . require a great mass of fire. The immensity of their spheres at times surpasses the size of the morning sun. Among these you may also include a phenomenon which we read about frequently in history: the sky seems to be on fire. Sometimes its glow is so high it appears to be actually among the stars. Sometimes it is so low that it gives the illusion of a fire some distance away. In the reign of Tiberius Caesar watchmen rushed to the aid of the colony at Ostia just as though it were ablaze, since throughout most of the night there had been a glow in the sky, dull, as of a thick smoky fire. Concerning these phenomena no one doubts that they have the flame which they show; there is a definite substance to them.[14]

The practice followed by all known post-Aristotelian writers on aurorae remained the same down to the end of classical antiquity.[15] It is fair to say that despite the steady accumulation of auroral observations, no real progress in theory or even in recognition of the common elements of auroral phenomena was made after the fourth century B.C. What had been definitely established, thanks largely to the work of Aristotle, was that the auroral light arises from the atmosphere and is emitted light rather than reflected sunlight (although a few ancient writers persisted in assigning the "beams" and "pillars" to the aether). Since the tools necessary for further progress, such as the spectroscope and suitable northern observatories,[16] were not yet available, speculation and analogy became the substitutes for a more scientific approach.

MODERN CATALOGUES

The modern phase of the study of ancient aurorae began in 1733 with the publication of Jean Jacques de Mairan's now classic textbook *Traité physique et historique de l'aurore boréale.* He and many of his successors tried to identify possible aurorae in the works of the better-known classical authors. In an effort to consolidate the subject, four authors published catalogues of ancient aurorae: Frobesius in 1739, Fritz in 1873, Schove in 1948, and Link in 1962.[17] Unfortunately, these catalogues

[14]Seneca, *Naturales quaestiones* I 14.1–15.5, trans. T. H. Corcoran, *Seneca: Naturales quaestiones* (Cambridge, Mass.: Harvard University Press, 1971). In Corcoran's translation I have introduced alternate renderings of a few of the technical words. It is unfortunate that the "sky fire" of Tiberius' reign (A.D. 14–37) cannot be more precisely dated.

[15]A chronological arrangement of these authors and a comparison of their opinions concerning fiery sky phenomena can be found, e.g., in Hartmann, *De Senecae,* and in Johannes Hemsing, *De Senecae naturalium quaestionum libro primo* (Monasterii Guestfalorum, 1913).

[16]Few ancient reports of aurorae in northern countries have come down to us. Three rather far-fetched examples have been suggested by S. Günther, "Das Polarlicht im Altertum," *Beiträge zur Geophysik,* 1903, *6*:98–107. As alternative explanations, I suggest that the northern "sea-lungs" of Pytheas of Marseilles (Strabo, *Geography* II 4.1) can be more easily interpreted as sea ice; the northern "rays" of Tacitus (*Germania* 45) as the permanent sunbeams on a summer night at high latitudes; and the northern "demons" of Plutarch (*De facie quae in orbe lunae apparet* 941F; cf. Pedo in the Elder Seneca, *Suasoriae* I 15) as indefinable in any context. Of uncertain nature also is the "falling sky" that the Celts feared (Strabo VII 3.8; Arrian, *Anabasis Alexandri* I 4.8). However, a good description of an aurora in Germany is couched in similar terms (Dio, *Roman History* LVI 24.3–4). Gallic aurorae are mentioned in the literature twice (Obsequens, *Prodigiorum liber* 38, 44); perhaps a third Gallic aurora is the same as the aforementioned German one, which seems to have extended as far south as the Alps.

[17]Johannes Nicolaus Frobesius, *Nova et antiqua luminis atque aurorae borealis spectacula* (Helmstadt: Weygandus, 1739); Hermann Fritz, *Verzeichniss beobachteter Polarlichter* (Vienna: Kaiserlichen Akademie der Wissenschaften, 1873); Derek Justin Schove, "Sunspots and Aurorae," *J. Brit. Astron. Ass.,* 1948, *58*: 178–190; František Link, "Observations et catalogue des aurores boréales apparues en occident de −626 à 1600," *Geofysikální Sborník,* 1962, No. 173, 1–96. Some aurorae are listed in the comet catalogue of Alexandre G. Pingré, *Cométographie* (Paris: Imprimerie Royale, 1783), Vol. I. Of no independent value

have turned out to be not only inaccurate but incomplete as well, chiefly because the compilers have drawn heavily and uncritically on several earlier collections of ancient prodigies, especially the vast collection made by the sixteenth-century scholar Lycosthenes.[18] Although Lycosthenes did not acknowledge his sources, the modern compilers have not bothered to find them out, except in a few obvious cases. Yet any of the ancient sources available to Lycosthenes must almost certainly be available to us today.

In order to illustrate the dangers of not resorting directly to the original literature (and, even then, dangers are not entirely to be avoided), I give the following four examples. The first refers to a prodigy listed by Lycosthenes that is reported in all four catalogues as the oldest aurora mentioned in classical literature. Lycosthenes writes tersely of "military spears burning in the sky late at night" (c. 503 B.C.). This prodigy can be traced to the *Roman Antiquities* of Dionysius of Halicarnassus, who gives further details that indicate an obvious case of static electricity playing on iron spearheads.[19] Lycosthenes also provides a second example: a manifestation of "sky warriors at Aegina" in the year 463 B.C. The original passage is due to Plutarch, who has skeptically described a vision of armed men leaving Aegina during the (daytime) battle of Salamis in 480 B.C.[20] Third among these examples is a report transmitted by the seventeenth-century scholar Nihusius that "the sky was ablaze for 70 days a little before the Peloponnesian war; whereupon Athens, after being pulled down to the tune of a flute, blazed up." The date is reported as 443 B.C., but the original passages are again found to be in Plutarch, and the date ought to be 467 (or 468) B.C.[21] Lastly, a passage quoted by the seventeenth-century scholar Vincentius runs: "burning clouds, falling like meteors from the sky, were seen by Alexander the Great in Egypt" (c. 332 B.C.). This fragment turns out to be an abstract from "Alexander's Letter to Aristotle," an undoubted forgery that is preserved in the Alexander Romance of pseudo-Callisthenes. The particular passage in question, even if it is based on fact, actually refers to a lightning storm near the borders of India.[22] Further examples from the published auroral catalogues would be superfluous; an entirely new catalogue is obviously needed, and it is provided below.

A NEW CATALOGUE

Difficulties of interpretation of the primary sources themselves cause problems enough. Clement of Alexandria, a late writer, refers to a "pillar of fire" that was seen in Greece in 404 B.C. Since he says that it appeared during a stormy night, it is unlikely to have been an aurora.[23] When Alexander's army reportedly saw the sky blazing the night before their final battle with the Persians (331 B.C.), Quintus Curtius

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are the fanciful lists of ancient aurorae compiled by Tito Nicolini, "Il periodo medio dell' attività solare in relazione alle osservatazioni antiche e moderne," *Rendiconto dell' Accademia di Scienze Fisiche e Matematiche in Napoli* (Ser. 4), 1942, *12*:79–88; "Sull'andamento secolare dell'attività solare," *ibid.*, 1976, *43*:1–11.

[18] Conradus Lycosthenes, *Prodigiorum ac ostentorum chronicon* (Basel: Oporinus, 1552).

[19] Dionysius of Halicarnassus, *Roman Antiquities* V 46.2. The passage from Lycosthenes is quoted by Frobesius, Fritz, Schove, and Link.

[20] Plutarch, *Themistocles* XV 1; see also Herodotus, *Histories* VIII 84. The passage from Lycosthenes is quoted by Fritz and, in a wrongly translated form, by Schove.

[21] Plutarch, *Lysander* XII 4, XV 4. Nihusius is quoted by Frobesius and, in an abbreviated form, by Fritz and Schove.

[22] Pseudo-Callisthenes, *Historia Alexandri Magni* III 17 (Kroll 111.3.n.). See also the Latin version of Julius Valerius, *Res gestae Alexandri Macedonis* III 35; versions also exist in Syriac, Armenian, Ethiopic, and other languages. Vincentius is quoted by Frobesius and Link, and alluded to by Schove.

[23] Clement of Alexandria, *Stromata* I 24; cf. Exodus 13:21–22, 14:24.

later took this conflagration to have been a celestial prodigy rather than the campfires of the enemy or the brushfires caused by the enemy's scorched-earth policy.[24] I reject, with Plutarch, the first interpretation. Livy's report of "scattered fires in the sky followed by a huge torch blazing out" (203 B.C.) is best read as an intense meteor shower with one particularly bright meteoric fireball.[25] Although an inverted order of physical development is reported by Cassius Dio for the comet of 12 B.C., the nightly persistence of this comet as a "torch" seems to preclude its having been in reality an aurora.[26] Tacitus describes "fiery clouds" illuminating the Temple at Jerusalem (A.D. 65?), but Josephus' account of what is probably the same event implies some kind of static electrical phenomenon. The two accounts can be reconciled by assuming that an outbreak of St. Elmo's fire occurred inside the Temple during an intense lightning storm at night.[27] Apart from these specific examples, I also reject the following *classes* of phenomena: daytime lights of all kinds, lightning from a clear sky, fiery globes, new stars, sky armaments, sky ships, and burning seas.[28]

What, then, are the phenomena that can safely be regarded as auroral (at least in most instances)? A systematic search of the classical literature reveals that most of the probable aurorae divide themselves neatly into just a few categories. These divisions are based on certain described forms, which reflect the ancients' view of aurorae and do not necessarily conform to the modern divisions. Therefore, it seems best to retain the original categories, since the ancient practice of using invariably the same descriptive formulae in reporting celestial prodigies suggests that the same physical phenomena (whatever they may be) are being reported over the centuries. In the order of their probable association with aurorae, the categories are:

X. Chasm (χάσμα, *hiatus* or *discessus*).

SF. Sky fire (οὐρανὸς φλεγυρός, *caelum ardens*).

NS. Night sun (ἥλιος or φῶς νυκτός, *sol* or *lux noctu*).

BR. Blood rain (ψεκὰς αἱματώδης, *pluvia sanguinea*).[29]

MR. Milk rain (ψεκὰς γαλάκτινη, *pluvia lactea*).[30]

B. Beam (δοκίς, *trabs*).

P. Pillar (κίων, *columna*).

T. Aurora-like torch (λαμπάς, *fax*).

K. Aurora-like comet (κομήτης, *stella crinita*).

[24]Quintus Curtius, *Histories* IV 12.14; Plutarch, *Alexander* XXXI 4–5.

[25]Livy XXX 2.11.

[26]Dio, *Roman History* LIV 29.8.

[27]Tacitus, *Histories* V 13.2; Josephus, *Jewish War* VI 5.3. Josephus' more reliable account was much quoted by later compilers, both ancient and modern.

[28]P. Bicknell, in "Globus Ignis," *Le monde grec: hommages à Claire Préaux* (Brussels: University of Brussels Press, 1975), pp. 285–290, has argued that a small percentage of the reported "fiery globes" could be aurorae. The other rejected categories could also contain a small number of aurorae.

[29]Some authors, including Cicero (*De divinatione* II 58), have ill-advisedly regarded "blood rain" as being in all cases simply contaminated water drops that have fallen to the ground; see, e.g., F. B. Krauss, *An Interpretation of the Omens, Portents, and Prodigies Recorded by Livy, Tacitus, and Suetonius* (Philadelphia: University of Pennsylvania Press, 1930), pp. 58–60. But, for one thing, the great frequency of reported "blood rains" argues against this particular interpretation. For another thing, the ancient scientific writers themselves have used the terms "red" and "bloody" in describing what we now know on other grounds to be auroral displays (Aristotle 342a35; Seneca I 14.2; Pliny II 97). Finally, the typical report that "blood rain" was seen in such and such a precinct can be read to mean simply that the viewer was stationed in that particular precinct. Except for the few cases where physical drops are specifically mentioned, I shall maintain an auroral interpretation of "blood rain."

[30]"Milk rain" is recorded only in Livy and his excerptors, and only for the period c. 265 to 92 B.C. Krauss, *An Interpretation,* pp. 65–66, interprets it as fallen raindrops, as he does "blood rain."

It should be emphasized that the ancient authors did not attribute to these categories a single underlying physical cause. This is a modern interpretation, based on a critical selection of sky phenomena that have been abstracted from a much larger number which the ancients described. In the previous auroral catalogues the last six categories have been ignored either partially or entirely.

It is impossible to be certain that every reported event belonging to each of these categories is an aurora. Sufficient detail in the ancient descriptions is nearly always lacking, and some of the events are probably due to other phenomena, such as noctilucent clouds, atmospheric dust, distant lightning, airglow, zodiacal light, meteor showers, and comets (in the modern sense). Of our three main ancient sources, Livy and his excerptor Obsequens only once report a "comet" and only once a "beam" (probably the terms were never used in the official Roman records and histories until Greek scientific knowledge became commonplace in Rome in the first century B.C.).[31] Thus, these two authors as well as our third main source, Cassius Dio, seem to use the word "torch" for all kinds of torchlike displays. Unless specific auroral properties are described, I have had to reject most of the reported "comets" and "torches."

The reports that are here accepted as being probably auroral are listed in Table 1.[32] A question mark placed after an assigned category indicates that the report as a whole, for one reason or another, cannot be regarded as auroral on its own merits. The collection of aurorae is quite homogeneous geographically: all the reported events occurred in Greece, Italy, or southern Gaul, with the exception of three questionable events, one in Egypt (30 B.C.), one in Judea (A.D. 30?), and one in Carthage (A.D. 212?).

The assigned dates depend in large part on the chronologies provided by the ancient authors reporting the events; for early Greece, either the annual Athenian archonship or the Olympiad and year number are usually reported, while for the Roman world the annual consulship, the emperorship and year number, or the year number since the founding of Rome is typically reported. Modern scholarship has been able to establish the necessary links between the ancient and modern systems of reckoning the years (by the help of ancient synchronisms and datable eclipses, for example). Since both the old Athenian year and the Roman year before 153 B.C. did not begin on January 1, and since there was a careless intercalation of months to fill the years before 45 B.C. as well as a poor tradition of the consular lists prior to circa 300 B.C. and even an occasional disagreement among the ancient authorities as to the date of an event, any modern attempt at exact dating is doomed to failure. Chronological accuracy is, in most cases, limited simply to the year of the event, the possible error of the date being ±1 year, especially for dates preceding the Julian calendar reform of 45 B.C.; dates in Table 1 that are more uncertain than this bear question marks. Of course, in any year more than one aurora may have been reported, although the general rarity of the reports makes this unlikely. Moreover, different

[31] The comet is Caesar's of 44 B.C. (Obsequens 68) and the "beam" occurred in 63 B.C. (Obsequens 61). A documented catalogue of "comets" and "torches" in classical literature has been assembled by W. Gundel, *s.v. Kometen,* in Pauly-Wissowa-Kroll, *Real-Encyclopädie der Classischen Altertumswissenschaft* (Stuttgart: Metzler, 1921), Vol. XI, Pt. 1, cols. 1143–1193.

[32] Lycosthenes lists a number of prodigies for the year 128 B.C. that I cannot locate in the ancient literature. He seems to imply that he drew these reports from Obsequens; but Scheffer thinks not, because they are not found in the Aldine edition of Obsequens. I have not included Far Eastern aurorae in Table 1; but some examples have been listed by S. Kanda, "Ancient Records of Sunspots and Auroras in the Far East and the Variation of the Period of Solar Activity," *Proceedings of the Imperial Academy of Japan,* 1933, *9*: 293–296, and by D. J. Schove, "Sunspots, Aurorae, and Blood Rain: The Spectrum of Time," *Isis,* 1951, *42*: 133–138.

Table 1. Documented catalogue of ancient auroral reports[a]

Year	Category[b]	References
B.C. 480	?	Pliny II 90 (K?); Lydus, *De mensibus* IV 73 (K?)
468/467	SF, B	Daimachus in Plutarch, *Lysander* XII 4 (SF); Charmander in Seneca VII 5.3 (B); Pliny II 149 (K?); Aristotle 344b34 (K?); Alexander of Aphrodisias, *ad loc.* (K?); Philoponus, *ad loc.* (K?); Olympiodorus, *ad loc.* (K?)
464/463?	SF	Livy III 5.14 (SF); Orosius II 12.2 (SF)
461?	SF	Livy III 10.6 (SF)
459?	SF	Dionysius of Halicarnassus X 2.3 (SF)
395/394?	B	Pliny II 96 (B)
373/371	B, T	Diodorus Siculus XV 50.2–3 (B, T); Callisthenes in Seneca VII 5.3 (B); *Parian Marble,* ep. 71 (T?); Pausanius VII 24.8 (T?); Aristotle 343b1, b18, 344b34 (K?); Alexander of Aphrodisias, *ad loc.* (K?); Philoponus, *ad loc.* (K?); Olympiodorus, *ad loc.* (K?); Aristotle in Seneca VII 5.4 (K?); Ephorus in Seneca VII 16.2–3 (K?)
350/349	X, BR, SF	Pliny II 97 (X, BR, SF); Lydus, *De ostentis* 10b (X, SF)
345/344	X, SF, T	Plutarch, *Timoleon* VIII 5–7 (X, SF, T); Diodorus Siculus XVI 66.3 (T); Pliny II 90 (K?)
265?	?	Orosius IV 5.1 (MR?); Paulus Diaconus II 16 (MR?)
223	SF, NS	Orosius IV 13.12 (SF, NS); Paulus Diaconus III 2 (SF,NS); Zonaras VIII 20 (SF, NS)
217	X, SF	Livy XXII 1.11–12 (X, SF); Orosius IV 15.1 (X); Paulus Diaconus III 9 (X); Plutarch, *Fabius Maximus* II 3 (X); Silius Italicus VIII 630–651 (X?, SF?, BR?, K?)
214	BR	Livy XXIV 10.7 (BR)
209	MR	Livy XXVII 11.5 (MR)
206	NS	Livy XXVIII 11.3 (NS)
204	NS	Livy XXIX 14.3 (NS)
200	SF	Livy XXXI 12.5 (SF)
198	SF	Livy XXXII 9.2 (SF)
197	NS	Livy XXXII 29.2 (NS)
183	BR	Livy XXXIX 46.5, 56.6 (BR); Obsequens IV (BR)
181	BR	Livy XL 19.2 (BR); Obsequens VI (BR)
172	BR	Livy XLII 20.5 (BR)
169	SF	Livy XLIII 13.3 (SF), 13.5 (BR?)
168	?	Seneca I 1.2 (K?)
166	NS, BR	Obsequens XII (NS, BR)
163	SF, NS, MR	Obsequens XIV (SF, NS, MR)
162	SF	Obsequens XV (SF)
147	SF	Obsequens XX (SF)
134	NS, BR	Obsequens XXVII (NS, BR)
130	MR	Obsequens XXVIII (MR)
128	BR	Obsequens (?) in Lycosthenes (BR, T?)
125	MR	Obsequens XXX (MR)
124	MR	Obsequens XXXI (MR)
118	MR	Obsequens XXXV (MR)
117	MR	Obsequens XXXVI (MR)
114	BR, MR	Pliny II 147 (BR,MR); Lydus, *De ostentis* 6 (BR, MR)

Year	Category[b]	References
113	SF, NS	Obsequens XXXVIII (SF); Pliny II 100 (NS)
111	MR	Obsequens XXXIX (MR)
108	MR	Obsequens XL (MR)
106	BR, MR	Obsequens XLI (BR, MR)
104	BR, MR	Obsequens XLIII (BR, MR, SF?); Plutarch, *Marius* XVII 4 (SF?); Pliny II 148 (SF?)
102	NS, BR	Obsequens XLIV (NS, BR)
95	MR	Obsequens L (MR)
94	SF	Obsequens LI (SF, T?)
93	X, SF	Obsequens LII (X, SF, BR?)
92	MR	Obsequens LIII (MR, BR?)
91	X, BR	Sisenna in Cicero, *De divinatione* I 99 (X, BR)
63	SF, B, K	Cicero, *In Catilinam* III 8 (SF); Cicero in Cicero, *De divinatione* I 18 (K, T?); Obsequens LXI (B); Dio XXXVII 25.2 (T?)
49	SF, BR	Lucan I 527–529 (SF, K?); Appian II 36 (BR); Dio XLI 14.3 (SF?); Pliny II 92 (K?)
48	B, P	Lucan VII 155–156 (B, P); Plutarch, *Caesar* XLIII 3 (T?); Appian II 68 (T?); Dio XLI 61.2 (T?); Zonaras X 9 (T?)
44	?	Ovid XV 788 (BR?)
42	SF, NS	Manilius I 907 (SF); Obsequens LXX (NS); Dio XLVII 40.2 (NS); Zonaras X 19 (NS); Vergil I 488 (K?)
32	T	Dio L 8.2 (T)
30	?	Dio LI 17.4–5 (BR?, K?)
B.C. 17	T	Obsequens LXXI (T); Dio LIV 19.7 (T)
A.D. 9	SF, P, K	Manilius I 901–902 (SF); Dio LVI 24.3–4 (SF, P, K)
14	SF, BR, K	Dio-Xiphilinus LVI 29.3 (SF, BR, K); Zonaras X 38 (SF, BR, K); Seneca VII 17.2 (K?)
30?	?	Pseudo-Pilate (NS?)
39?	BR	*Oracula Sibyllina* X 56–57 (BR)
50	SF	Dio-Xiphilinus LX 33.2 (SF); Zonaras XI 10 (SF)
54	BR	Dio-Xiphilinus LX 35.1 (BR)
76	K	Titus in Pliny II 89 (K)
185?	?	Lampridius, *Commodus* XVI 2 (SF?); Herodian I 14.1 (K?)
196	SF	Dio-Xiphilinus LXXV 4.6 (SF)
212?	?	Tertullian, *Ad Scapulam* III (SF?)
300?	?	*Oracula Sibyllina* XII 89–90 (BR?)
333	SF	Aurelius Victor XLI (SF)

[a]**Sources:** Alexander of Aphrodisias, *In Aristotelis Meteorologica*; Appian, *Civil Wars*; Aristotle, *Meteorologica*; Aurelius Victor, *Caesars*; Cicero, *De divinatione, In Catilinam*; Dio-Xiphilinus, *Roman History;* Diodorus Siculus, *Library of History*; Dionysius of Halicarnassus, *Roman Antiquities*; Herodian, *Ab excessu divi Marci*; Lampridius, *Vita Commodi (Historia Augusta)*; Livy, *Ab urbe condita*; Lucan, *Pharsalia*; Lydus, *De mensibus, De ostentis;* Manilius, *Astronomicon*; Obsequens, *Prodigiorum liber*; Olympiodorus, *In Aristotelis Meteorologica*; Anonymous, *Oracula Sibyllina*; Orosius, *Adversum paganos*; Ovid, *Metamorphoses*; Anonymous, *Parian Marble*; Paulus Diaconus, *Roman History*; Pausanias, *Description of Greece*; Philoponus, *In Aristotelis Meteorologica*; Pliny the Elder, *Naturalis historia*; Plutarch, *Parallel Lives*; pseudo-Pilate, *Report to Caesar*; Seneca, *Naturales quaestiones*; Silius Italicus, *Punica;* Tertullian, *Ad Scapulum;* Vergil, *Georgics;* Zonaras, *Annals.*

[b]**Categories:** B = beam; BR = blood rain; K = aurora-like comet; MR = milk rain; NS = night sun; P = pillar; SF = sky fire; T = aurora-like torch; X = chasm.

reports for the same year may, in some instances, refer to entirely different phenomena. On the other hand, not all the reports are of independent value, because later authors have necessarily borrowed from their predecessors. Finally, it is typical that more reports tended to be generated, or later remembered, during times of stress and of other notable events.

A few comments about the three largest gaps in the auroral record seem to be called for, since some authors, such as Schove, have identified these gaps with aurorally quiet periods.[33] The first gap occurs in the Roman record between 459 and 223 B.C. Our main reference for this period, Livy's history, suffers both from a dearth of reliable early records in his time (due in part to the burning of Rome by the Gauls c. 390 and in part to the irregularity of the Roman pontifical annals before c. 300) and also from the loss in postclassical times of those intermediate books of his history that cover the years 292 to 220. However, aurorae did occur during at least the earlier half of this long period, as is demonstrated by the four examples of Greek aurorae preserved by later Roman writers. Yet not a single aurora from the fourth and fifth centuries is reported in the great contemporary Greek histories that are still extant; this silence is undoubtedly due to those historians' very sober attitudes toward portents of all kinds. The second gap in the auroral record falls between 91 and 49 B.C. (with the exception of the year 63 B.C.). As may be judged by Obsequens' extracts from Livy's history, the unprecedented civil wars of that period bred a growing public disrespect for portents[34] and apparently interrupted the transmission to Rome of reports of many aurorae that must nonetheless have been noted. Finally, the series of gaps after A.D. 76 is at least partly due to the well-known paucity of historical records for the late Roman Empire. In sum, I can find no good historical evidence either for or against the supposition that the gaps in the record are associated with aurorally quiet periods.

THE ANCIENT AURORAL CYCLE

Because of the fragmentary nature of the auroral record in Table 1, standard methods of analyzing this record for possible periodicities fail. Thus, Nicolini, Schove, and Link simply assumed in their work an eleven-year cycle of variability in analogy with the modern auroral and sunspot cycles.[35] In part, their failure stemmed from not having had an adequate catalogue. Schove listed, for the period before A.D. 300, only thirteen auroral years that he regarded as suitable for mathematical analysis; of these, a mere six lay in the well-documented interval 223–91 B.C. But I find thirty-six useful auroral years in the latter time interval.

With the help of an appropriate method of time series analysis, I have recently searched for possible cycles in the ancient auroral data. Since the results of this analysis have already been presented,[36] it suffices here merely to summarize the main points. First, there were sufficient data in the interval 223–91 B.C. to analyze separ-

[33] D. J. Schove, "The Sunspot Cycle, 649 B.C. to A.D. 2000," *Journal of Geophysical Research,* 1955, *60*:127–146.

[34] For other causes see Krauss, *An Interpretation.*

[35] Nicolini, "Sull' andamento secolare dell' attività solare"; Schove, "The Sunspot Cycle"; F. Link, "Manifestations de l'activité solaire dans le passé historique," *Planetary and Space Science,* 1964, *12*: 333–348. Pliny (II 97) originally suggested that "chasms," "beams," and the like were periodic phenomena, but in this opinion he was simply following Pythagorean and Chaldean cometary tradition.

[36] R. Stothers, "Solar Activity Cycle during Classical Antiquity," *Astronomy and Astrophysics* (in press). This research has depended heavily on the classics collections of the Columbia University Libraries and the New York Public Library.

ately the categories of "sky fire," "night suns," "blood rain," and "milk rain." These categories showed virtually the same period of cyclical variation, suggesting that they were merely different manifestations of the same phenomenon. The mean period was 11.5 years, with a scatter of less likely periods ranging from 8 to 13 years. A longer period of 80 to 100 years was also present in the data. Second, it was found that the average frequency of visible aurorae near Rome was approximately three per decade. Since these results resemble so closely the characteristics of modern aurorae, it would seem that the second century B.C. was very similar to our own century as far as aurorae are concerned.

CONCLUSION

Whatever merit may exist, for us today, in the numerous examples of celestial prodigies recorded during the later centuries of antiquity, it is clear that auroral science in the ancient West made no significant progress in either classification or theory after the age of Aristotle. Insuperable technological barriers stood in the way at the time, as did the unavoidable fact that visible aurorae are rare and of short duration in the Mediterranean area. Moreover, the apparent unpredictability of aurorae made them less interesting to the ancients.

It has been left to modern science to devise a formal classification scheme for these neglected legacies from antiquity. The system proposed in this paper is believed to be the simplest and most useful of those that have been suggested, as it is very close to the one used by the ancients themselves in classifying the various observed kinds of unusual celestial phenomena. Underlying any system, of course, is the tacit assumption that ancient and modern aurorae look the same visually.

With the help of a new survey of the classical literature, I have put together an extensive catalogue of reports of what are likely to have been auroral displays. This catalogue certainly has statistical value, even though individual entries may be rather uncertain. It appears possible, from this catalogue, that auroral activity was continuous at some level of visibility throughout recorded antiquity. In fact, during the best-documented period—the second century B.C.—the auroral cycle seems to have been very similar to what it is today.